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Uses, Threats and Conservation of Plant Species in Kisere Catchment Area of Kakamega Forest, Kenya

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Abstract: ***Tropical rainforests are under threat from human encouragement and anthropogenic activities in sub-Saharan Africa. Despite the importance of tropical rainforests, anthropogenic activities are changing vegetation dynamics of tropical rainforests such as Kakamega forest. The aim of the study was to determine the most exploited tree species in Kisere Forest by the local communities and their uses; to assess the impact of anthropogenic activities on plant species in Kisere Forest, to evaluate the contribution of Village Economic Enterprises on conservation of Kisere Forest. To determine the most targeted tree species by the local communities and their uses, semi-structured questionnaires were used and ethno-botanical survey was conducted. The Impact of Village Enterprise funded microenterprises on conservation of Kisere Forest was determined by comparing exploitation of the forest by funded households and unfunded households. This was done by assessing the time spent in the forest and the frequency of visiting forest to collect forest products and the collection of forest products for sale versus subsistence by the funded and unfunded households. Impacts of Village enterprise was also assessed by monitoring trends in forest disturbance. It was found out that most plant species were used for firewood, poles, charcoal burning and source of medicine. Integrated conservation strategies aimed at providing people living around biodiversity hotspots with knowledge, skills and economic opportunities should be encouraged so that local communities can live sustainably with the forest ecosystems and protect local resources against future threats.***

Keywords: Anthropogenic, Harvesting, Local communities, *Prunus africana*, Tropical forests

1. Introduction

Kisere forest is one of the few existing fragments of the larger Kakamega tropical rain forest. It is surrounded by a densely populated local community hence is under intense pressure from anthropogenic activities (Mitchel, 2004; Kiplagat *et al*, 2008). Kisere Forest is a fragment of Kakamega Forest to the north. It is managed by Kenya Wildlife Service (KWS), but the forest rangers are stationed at Buyangu station which is about 30 kilometers from the Kisere Forest (Chism and Cords, 1998). Roads leading to Kisere Forest are poorly maintained which makes surveillance and enforcement forest laws difficult. Local communities easily access the forest to obtain forest products both for subsistence and commercial purposes due to lack of surveillance by the rangers. The products include firewood, medicines, poles, vegetables fruits and honey and timber (Kiplagat *et al*, 2008).

The research aimed at determining the impact of human activities on the density, regeneration and distribution of most targeted tree species in Kisere Forest by the local communities around it and to assess the impact of Village Enterprise on conservation of Kisere Forest. Village Enterprise is a non-governmental organization that funds the rural poor to alleviate poverty with a view of improving environmental conservation. Village enterprise I partnership with Jane Goodall institute, The Budongo conservation field station and other conservation organizations have expanded their model to create an integrated microenterprise programme that empowers individuals and surrounding communities. It has promoted chimpanzee and forest conservation and lift local income levels in Budongo, Uganda. Several households around Kisere Forest have received funding from Village Enterprise.

Kisere Forest is a fragment of Kakamega forest and faces threats associated with intense human activities in the area. These communities threatens the forest through fuel wood collection, charcoal burning, illegal pit-sawing, hunting, collection of medicines, construction poles and cattle grazing. About 20 percent of all Kenyan plants and animal species are endemic to Kakamega Forest. Studies have shown that such practices can affect forest structure and composition. Researches in Ugandan forest have shown that regeneration in a logged forest may remain poor for even more than 20 years after (Fashing et al 2004). Chism and Cords 1996 had noted that local communities were using the national reserve indiscriminately for firewood, grazing cattle, poles for construction, timber and charcoal. He cited lack of surveillance due to far location of KWS rangers station coupled with poor road system. This situation remains the same to date. Kakamega Forest is the only forest with tree species such as *Bequaertiodentron oblanceolantum, Morus mesozogia, Typhlops madagascariense and Funtumia latifolia*. The research was carried out to determine how the intense human activities affect the regeneration, density and distribution of tree species in Kisere Forest

This research was based in Kisere Forest which is about 450 ha hence will reflect what is happening in the entire Kakamega Forest. Exploitation of forest products by adjacent communities is a major challenge to the conservation of biodiversity in tropical rain forests (Millet and Luu, 2011). Long term understanding of tree population's dynamics is critical in increasing our understanding of conservation needs of tropical rainforest ecosystems. However little of such studies been done in majority of tropical rainforests including Kakamega forest

(Fashing et al 2004). There is need therefore to understand the impacts of anthropogenic activities on tropical rainforests in order to put in place viable conservation plans. This research is an eye opener on the conservation status of Kisere Forest where little research has been done. The study also assessed the achievements of the Village Enterprise on conservation of Kisere Forest. The research findings will be of benefit to KWS in the management and conservation of biodiversity in Kakamega Forest. It has revealed the extent of disturbance in the Forest and the conservation interventions by Village Enterprise in Kisere Forest. The data obtained will be of great use in prioritizing conservation interventions by KWS that manage and conserve the forest fauna and flora. The aim of the study was to: determine the most exploited tree species in Kisere Forest by the local communities and their uses; to determine the impact of anthropogenic activities on plant species in Kisere Forest and to evaluate the contribution of Village Enterprise on conservation of Kisere Forest as well as to determine whether the existence of the Village Enterprise funded micro-enterprises had an impact on the rate of disturbances of Kisere Forest by the local community members.

2. Methods and Materials

2.1 Study area

Kisere Forest National Reserve is in Kakamega County, Kenya (34.89°E and 0.4°N) as shown in Figure 1. It is a 4.6 km^2 forest 'island' separated from the main Kakamega Forest by small scale farming community (Chism and Cords, 1998). It was established as National Reserve in 1986 under management of Kenya Wildlife Service (KWS) (Blackett, 1994; Von, 2005). The Forest is a remnant of Guinea – Congolian rainforest at an altitude of 1500-1700 m above sea level (Kokwaro, 1998). Average annual rainfall is about 2000mm with temperatures ranging between 11°c and 27°c in both the rainy season (April –November) and dry season (December –March) (Mitchel *et al*., 2008). The soils of the surrounding land are moderately fertile clay-loam mixture which makes agricultural activities successful (Tsingalia, 1988). This has over time led to a dense population hence an increase in demands on the forest. The population density of the surrounding communities is high, about 550 people per square kilometer (Kiplagat *et al*, 2008). Tree species common in Kisere Forest include *Deinbolla kilimandscharia, Markhamia lutea and Antiaris toxicaria (*Vuyiya *et al*., 2014).

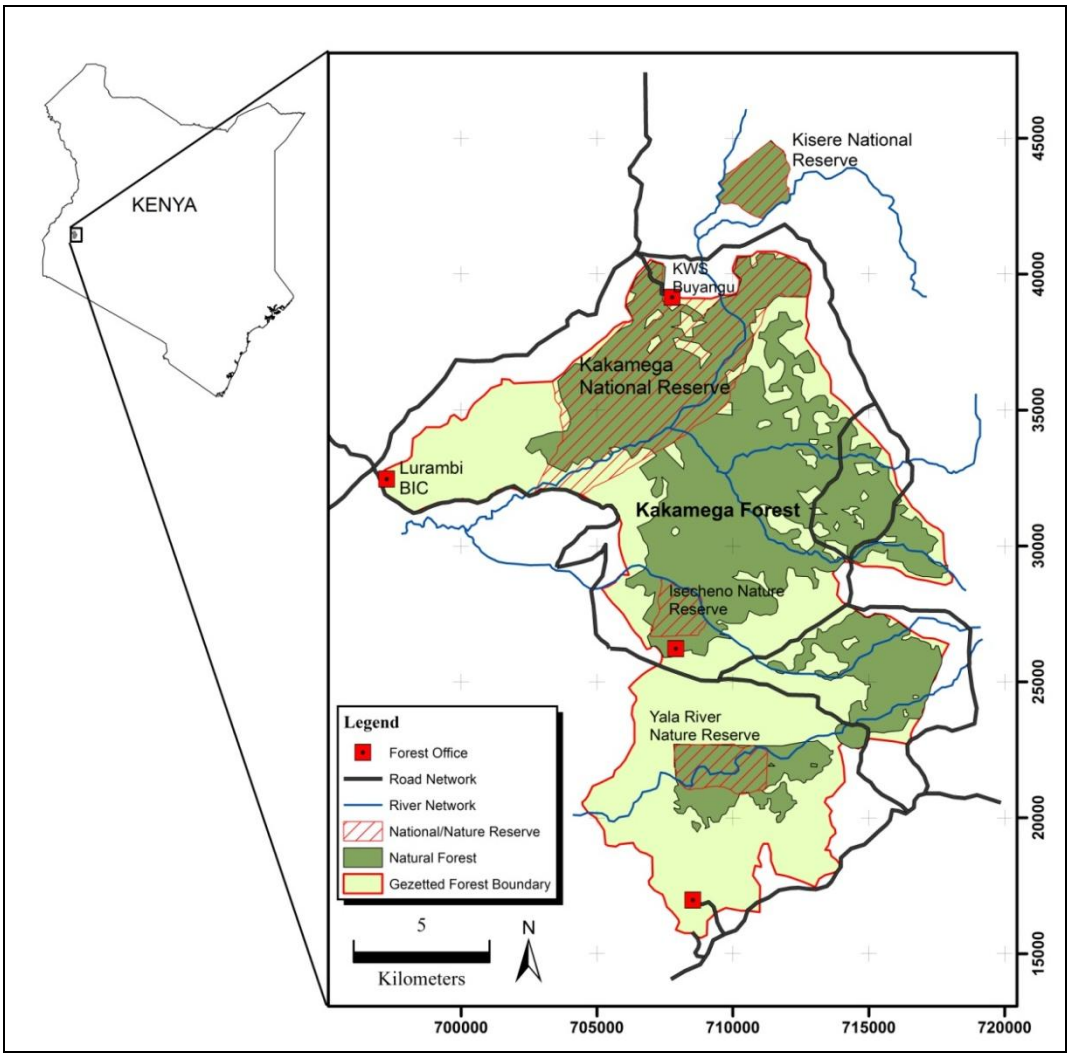

Figure 1: Location of the study area (Source: Nambiro, 2000).

2.2 Methods of data collection and analysis

The research was carried out in the Kisere Forest and in the four villages around it. Semi-structured questionnaires were used to determine the most targeted tree species by the local communities and their uses. (Kiplagat *et al*, 2008). To determine the sample size of the population the formula; $n=N/\sqrt{1+N}$ (e) ^{2} was used (Mmom and Arokoyo, 2010). Where;
n= Sample size.
N= Total population.
E= Error term=1= constant

The ethno-botanical survey was coded as follows: Tissue code (TC) =Part of plant used, stems=1, fruit/seed=2, bark=3, leaves=4, roots=5, other =6. Tree names were be recorded using local languages in the field and later identified by their scientific names in the herbarium (Tsingalia, 1988).

The Impact of Village Enterprise funded microenterprises on conservation of Kisere Forest was determined by comparing exploitation of the forest by funded households and unfunded households. This was done by assessing the time spent in the forest and the frequency of visiting forest to collect forest products and the collection of forest products for sale versus subsistence by the funded and unfunded households. In addition materials obtained from the forest will compared to those obtained from interviewee's own farm and other areas other than the forest (Godoy *et al*, 1993; Deland, 2006). Impacts of Village enterprise was also assessed by monitoring trends in forest disturbance in terms of logging, charcoal burning, uprooting,, livestock grazing and pit sawing in Kisere Forest over a period of seven months, from September 2012 to March 2013.

3. Results

3.1 The most targeted tree species and their uses in Kisere forest

Questionnaires were administered to 120 respondents across the four villages around Kisere forest to determine the most targeted tree species and their uses. *Funtumia latifolia* was ranked top most at 63.50%, *Markhamia lutea* 59.5%, *Prunus africana* 48.50%, *Olea capensis* 44.17% and *Croton macrostachyus* 24.17 %. In total 21 tree species were identified as the target tree species by people leaving around Kisere forest. On the uses of the four most targeted tree species, it was found out that *Funtumia latifolia* is mostly used for firewood 73.1%, *Markhamia lutea* is used mainly for poles 29.3%, firewood 28.6% and medicine 20.8%. *Olea capensis* is mainly targeted for timber 54.1% and firewood 29.4%. We also found out that *Prunus africana* is targeted most commonly for medicine 32.45%, charcoal 25.6% and firewood 24.5% (Table 1)

Table 1: Percentage usage of most targeted tree species. (N=120)

	Funtumia latifolia		*Markhamia lutea*		*Olea capensis*		*Prunus Africana*	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Medicine	52	15.3	70	20.8	37	11	109	32.4
Charcoal	34	10.1	28	8.3	8	2.3	89	25.6
Firewood	247	73.1	97	28.6	100	29.4	82	24.5
Poles	5	1.5	99	29.3	11	3.2	0	0
Timber	0	0	44	13	182	54.1	58	17.5
Total	338	100	338	100	338	100	338	100

The main part exploited for the four most targeted tree species was the stem at 75.7% for *Funtumia latifolia*, 83.4% *Markhamia lutea*, 77.8% for Olea capensis 62.1% for *Prunus africana*. *Prunus africana* also scored relatively high in use of the bark at 37.3% and 22.2% for *Olea capensis*. Root usage was low for the four most targeted tree species where *Funtumia latifolia* scored 6.2% and 0% for the other three species. Leaf usage was also low with *Markhamia lutea* scoring 13% and the other three species scoring 0% (Table 2).

Table 2: Percentage of parts used for the most targeted tree species (N=120)

	Funtumia latifolia		*Markhamia lutea*		*Olea capensis*		*Prunus Africana*	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Stem	256	75.7	282	83.4	263	77.8	212	62.7
Root	21	6.2	0	0	0	0	0	0
Bark	61	18.1	12	3.6	75	22.2	126	37.3
Leaf	0	0	44	13	0	0	0	0
Total	338	100	338	100	338	100	338	100

The study showed that there was a significant difference in seedlings density between study sites (DF = 4, F = 6.81; P < 0.0001), distance (DF = 2, F= 25.15; P < 0.0001) and species (DF =3, F=3.41; P < 0.0001). There was a significant difference in seedling density within sites with distance into the forest (DF = 8, F = 4.21; P < 0.0001), between species within sites (DF = 12, F = 3.41; P < 0.0001) and between species with distance into the forest (DF = 6 = F = 2.25; P = 0.0369)

3.2 Comparison of funded versus unfunded households exploitation of Kisere forest

No significant difference existed between the two groups in terms of gender (χ^2= 0.264, df = 1; p = 0.608), materials used to construct walls (χ^2= 4.79, df = 1; p = 0.08), Materials of the roof (χ^2 = 1.939, df = 1; p = 0.164), and source of main fuel (χ^2= 5.594, df = 2; p = 0.064) as show in Table 3.

Table 3: Pearson Chi-square test comparing VE households with Non VE households

Variable	χ^2 Value	DF	P
HH head gender	0.264 (b)	1	0.608
Number per HH	1.223	6	0.976
Wall material	4.79	1	0.808
Roof material	1.939	1	0.164
Wall material source	0.059	1	0.808
Roof material source	3.993	2	0.136
Source of main fuel	5.594	2	0.061

Comparison of the two groups in terms of how they used products from Kisere forest showed that there was a significant difference in medicine (χ^2= 8.911, df = 3; p = 0.03), where funded households used 59% for subsistence and 36.1%for both subsistence and sale while unfunded households used 48.3% for subsistence and 51.7% for both subsistence and sale. Fuel wood significantly differed (χ^2 = 13.269, df = 3; p = 0.004) funded households used 62.3% subsistence and 36.1% for both sale and subsistence while unfunded households used 48.3% for subsistence and 51.7% for both subsistence and sale (Table 4). Use of vegetables also differed significantly between the two groups (χ^2= 8.522, df = 3; p = 0.036) as shown in Table 4 where funded households scored 49.2 % for no uses, 31.1% for sale and 16.4 % both for subsistence and sale whereas unfunded households scored 27.5% for no uses, 41.7 % for sale and 25% for both subsistence and for sale. However, no significant difference was found in use of charcoal (χ^2=7.748, df = 3; p = 0.052), poles (χ^2 = 3.412, df = 3; p = 0.332), ropes (χ^2= 1.563, df = 2; p = 0.458) and bush meat (χ^2= 0.708, df = 1; p = 0.036) see Table 4. In terms of ranking Kisere forest based how the household value Kisere forest, there was no significant difference between the two groups in forest beauty (χ^2= 0.188, df = 1; p = 0.665), climate/rain (χ^2= 0.241, df = 2; p = 0.887), products for subsistence (χ^2= 0.644, df = 4; p = 0.958), products for sale (χ^2= 0.15, df = 4; p = 0.997) and soil fertility (χ^2= 0.098, df = 4; p = 0.999) as shown in Table 5. We found a significant difference in between funded households and unfunded households in frequency of obtaining forest products (χ^2=13.52, DF = 5; p = 0.019) and ranking of Village enterprise conservation efforts in Kisere forest (χ^2 = 61.744, DF = 3, p = 0.031).

Table 4: Comparison between Funded and Unfunded Households around Kisere forest based on the use of forest products

Variable	X^2 Value	DF	P
Medicines	8.9	3	0.03
Fuel wood	13.27	3	0.004
Charcoal	7.15	3	0.052
Poles	3.41	3	0.332
Ropes	1.56	2	0.458
Vegetables	8.52	3	0.036
Bush meat	0.71	1	0.4
Conservation awareness	0.88	1	0.665
Frequency of obtaining forest products	13.52	5	0.019
Ranking VE conservation efforts	61.74	3	0.031
N of valid cases	181		

Table 5: Pearson Chi-Square Comparing value of the Kisere forest to the Funded and Unfunded households

Variable	X^2 value	DF	P
Beauty	0.18	1	0.67
Climate/rain	0.24	2	0.89
Products for subsistence	0.64	4	0.96
Products for sale	0.15	4	0.99
Soil fertility	0.09	4	0.99
N of valid cases	181		

4. Discussion

4.1 Most targeted tree species and their uses

The study showed that there are four most targeted tree species in Kisere forest, which are *Funtumia latifolia*, *Markhamia lutea*, *Prunus africana* and *Olea capensis* respectively. The four species scored the highest percentage of above 44 percent as the most targeted tree species from Kisere forest. *Croton macrostachyus* was fifth at 24.8 percent. These tree species have a relatively high wood density of 4.5kg/dm^3 (*Funtumia latifolia*), 0.45kg/dm^3 (*Markhamia lutea*), 0.9kg/dm^3 (*Olea capensiss*) and 0.49kg/dm^3 (*Prunus Africana*) and this makes them good for fuel-wood, timber, poles and charcoal (Bwambok & Konje, 2021). Earlier research found these tree species to be among the most targeted around tropical forest (Vuyiya *et al*., 2014, Koros *et al.*, 2016a).

Funtumia latifolia was harvested mainly for fuel wood, this is because this tree species is easy to cut down and split. It also takes a very short time to dry and be used as fuel-wood unlike other tree species that need a long time to dry. These findings are in line with Tsingalia (1988) whereby he recorded *Funtumia latifolia* as the most preferred tree species for firewood in most sections of Kakamega forest. Though *Funtumia latifolia* stem density is currently the highest, the rate at which it is being exploited might see its stem density reduce drastically in the near future. *Markhamia lutea* is mainly used by the locals for fuel-wood and poles. *Markhamia lutea* stems when cut usually sprout into many straight slender poles that are good for fencing and construction of houses and stores. *Prunus africana* scored higher in medicinal uses (Koros *et al*., 2016b). This is line with past studies which have found the bark of *Prunus africana* to contain active medicinal ingredients that include phytosterols (Hallberg *et al*, 2000). Traditional medicinal uses of the bark of *Prunus africana* include treatment of stomach aches, urinary and bladder infections, chest pains, malaria, prostate cancer and kidney diseases (Hallberg *et al.*, 2000). The other three most targeted tree species scored low in terms of medicinal uses and the targeted parts are mainly the leaves and the roots. Apart from *Prunus africana* in which both the bark and the stem are mainly harvested, all the three most targeted tree species had the main part that was harvested to be the stem. This means that the entire tree is usually cut down which endangers trees more compared to harvesting parts of the tree such as leaves, roots or fruits. The main use of the trees harvested is fuel-wood, charcoal, poles and timber which indicates that the entire tree is cut down to obtain these products, such uses dictates that the all tree be cut down for utilization.

4.2 Impact of Village enterprise (VE) on conservation of Kisere forest

Village Enterprise is a NGO that fund micro-businesses among the rural poor with a view of conserving the environment by alleviating poverty. Impact of village enterprise on conservation of Kisere forest was done by assessing disturbance trends in Kisere forest over a period of seven months. This period run from September 2012 to March 2013. The disturbance level generally increased during the period of study, but the increase was highest in December. This was attributed to school going children who are usually at home during December holidays. Many parents send their children to forest to collect forest products on their behalf and others do on their own. A research done by Kiplagat et al. (2008) on section of Kakamega forest under Kenya forest service found that use of non-forest timber products also increased during school holidays. They reported that more children went to the forest over weekend and during holidays when they were away from school. Disturbance between December 2012 and March 2013 did not significantly vary though mean disturbance showed an increase through this period. The most common mode of disturbance as by the study during the study period was logging. Logging impacts very negatively on forests because it involves cutting down of the entire tree as opposed to where part of the tree is harvested (Kiplagat *et al*., 2008). Generally we concluded disturbance in Kisere forest was still high and ongoing.

Impact of Village Enterprise was on conservation of Kisere forest was also assessed by comparing the Village Enterprise funded households and the unfunded households on how they use Kisere forest for their livelihoods, the frequency of visiting the forest to collect forest products, type of products obtained and the their awareness on the significance of Kisere forest. House construction materials of the walls are mainly wood and mud for both unfunded households and funded households. Similar findings have been reported in other sections of Kakamega forest where up to 84 percent of the houses were made of mud and wood (Vuyiya et al., 2014).37.5% of the unfunded household heads mentioned Kisere as source of construction materials for their houses while 22.2% of VE HH depends on Kisere forest for the same. Funded households dependency on Kisere forest was lower in medicine, products for both subsistence and sale, and frequency of visiting the forest for collection of forest products. The lower percentage of forest dependency by funded households was mainly due to sensitization on the need to conserve the forest done Village enterprise personnel during their weekly meetings with the members. Funded households had their income improved by the funded micro businesses. Funded households low frequency of visiting the forest could be because they were spending more time in the businesses. These findings corroborate with Riana *et al*., (2009) findings in Arabuko Sokoke forest, where farmers who were involved in apiculture and sericulture had reduced the number of times they went to the forest to cut trees and burn charcoal.

Both funded households and non-funded households gave firewood (100%) as the main source of fuel for cooking in their homes and also 100% in both cases uses traditional stoves for cooking. Vuyiya *et al*., (2014), in their research around Kakamega forest recorded 98.5% of the house hold were relying directly on wood as a major source of energy for cooking purposes. The use of traditional jikos wastes much fuel wood which implies that more trees are cut down for fuel wood. Though a smaller percentage of both funded households and unfunded households heads mentioned Kisere as the source of fuel wood, it was not true because the study showed a large percentage of trees of lower DBH in Kisere forest were cut which are mainly used as fuel wood. Many of the cut stems were of *Funtumia latifolia* which was mentioned by almost all the house hold heads (73.1%) as the main tree species cut for fuel wood. Though funded household heads spent less time in the forest compared to unfunded household heads, the fact they depend equally on firewood for cooking may imply that they are using part of their income to buy firewood from Kisere forest. Funded households are likely to be therefore indirectly impacting negatively on Kisere forest using income accrued from their businesses to buy forest products such as fire wood. In fact 62.2% of the funded households mentioned Kisere forest has a source of fuel wood for subsistence.

Comparing how funded and unfunded households use products from Kisere forest, a higher percentage of the unfunded households used products from Kisere forest mainly for both subsistence and for sale while the funded households used mainly for subsistence. The lower percentage use of forest products for both sale and subsistence by funded shows that they are impacting less negatively on Kisere forest compared to unfunded households. The reason why a smaller percentage of funded households depend on Kisere forest for commercial purposes could be because they have an alternative source of income from their Village Enterprise funded micro-businesses. Studies done in India showed that increased credit availability for micro businesses have successfully alleviated poverty of forest dwellers which led to reduced forest exploitation (Pankaj, 2009). KEEP has similarly reduced dependency of Kakamega forest by offering alternative sources of income to its members through micro businesses based on non-timber forest products such as butterfly farming, snake keeping for tourism, bee keeping and tree nurseries (Lung, 2009). Funded households also less frequently visited the forest to collect forest products compared to unfunded households, this is because they spent more time in their Village enterprise funded micro businesses while majority of the unfunded households go to the forest to collect products both for sale and subsistence. This is confirmed by the fact that unfunded households used most of their forest products both for sale and subsistence. For example, while unfunded households used 51.7% of medicine, 24.2% of charcoal and 60.0% of fuel wood both for sale and subsistence, only 36.0% of medicine, 18.0% of charcoal and 32.8% of fire wood was used by funded households. The two groups however ranked Kisere forest highly in terms of significance like beauty, climate/ rain and soil fertility (Bwambok & Konje, 2021). This shows that communities around Kisere forest value but their low income levels is the driving force to their indiscriminate forest destruction.

5. Conclusion

From this study, it is very clear that people living around Kisere forest are extremely dependent on it for their livelihoods on daily basis. Kisere forest is a source of both products for subsistence and commercial use for supplementing household income. The products obtained from the forest range from fuel wood, livestock grazing, herbal medicines, construction poles, charcoal, timber and vegetables. Kiplagat et al 2008 studies on non-timber forest products (NTFP) doubted the low mentioning of KWS forest sections as source of NTFP by the locals. His doubts were confirmed by our studies in Kisere forest from the high level of disturbance recorded in the forest. Because the major products sourced from the forest are fuel wood, poles for construction, medicines, and animal grazing. It therefore follows that small and medium size DBH trees are over harvested leading to poor recruitment of the target tree species. Herbal medicine extraction and cattle grazing greatly interferes with the forest under growth and reduces seedlings survival to saplings that later would grow to form the forest canopy. There are also high chances that specific target tree species may in the near future disappear from this forest. This is shown by the extremely low seedling density of *Prunus africana* and *Olea capensis.*

Sustainability of the forest will be secured by moving from single asset system, where timber, fuel wood, pole extraction, charcoal production, cattle grazing, food and herbal medicine source are seen as the only real value of forest to multiple –asset approach which recognizes the wide variety of values, thus maximizing both conservation and economic returns in the investments (Riana *et al.,* 2009). In Kisere forest, the use of the forest is far away from realizing such achievements. The communities around the forest only use the forest for timber and non-timber forest products, such uses are very unsustainable insofar as forest conservation is concerned. The Village enterprise funded enterprises have had some positive impact on conservation of biodiversity in Kisere forest. Though the impact on conservation of Kisere forest by the time the studies were done was small, given time it might increase greatly. By the time the studies was done the Village enterprise had been there for barely two years which was relatively a short time for its impacts to be very clear. Village enterprise great success in conservation of chimpanzee and Budongo forest in Uganda was achieved through integrated microenterprise programme that empowers individuals in the surrounding communities economically. Village enterprise goal of providing people living around biodiversity hotspots with knowledge, skills and economic opportunities so as to live sustainably with the forest ecosystems and protect local resources against future threats, should be emulated by other conservation organizations and governments.

The almost zero disturbance of Buyangu forest was to a greater extend attributed to its proximity to KWS offices were the rangers provided security to the forest throughout. Bwambok & Konje, (2021) had noted that the KWS rangers charged with patrolling the forest were located far (20 km over poorly maintained roads) made it difficult to provide adequate surveillance. Currently the roads are even worse due to heavy tractors that transport sugar cane to sugar mills from farms around Kisere forest.

6. Recommendations

From the findings in Kisere forest study, we recommend that households around Kisere forest should be supported to plant trees that can substitute the forest target tree species. This should be fast growing tree species like *Eucalyptus saligna* and other indigenous species. More research should be done on the possibility of domesticating forest herbal plants such that farmers can grow them for subsistence and commercial purposes on-farm.

Value addition of products should be encouraged such the farmers can be supported to process and package medicinal products from the domesticated forest plants. This has been done successfully on southern sections of Kakamega forest by K. E. E. P with the technical assistance of ICIPE. About 80% of the households around Kisere forest depend on household farms as the only source of income where main crop is sugarcane.

The community around Kisere forest should be assisted so as to diversify their income source. This has been pioneered by Village enterprise but there is need for more conservation groups to come in. Income generating activities that does not interfere with the forest ecosystem can be encouraged at household level or among organized groups. Such activities include apiculture and sericulture. The Arabuko Sokoke project found out that honey collected close to the forest has double yields and quality (fructose and glucose) than honey collected 3-5 km away (Riana *et al.,* 2009). Cattle farmers should be encouraged to grow fodder crops for their animals adopt modern dairy farming that is more profitable like zero grazing. Such enterprises will motivate communities to conserve Kisere forest biodiversity and protect environment as well as increasing their economic wellbeing. However, some microenterprise proprietors may lack knowledge and skills to produce items as by market demand promotion based training is needed to upgrade knowledge and microenterprise skills.

There is a need to establish a Kenya Wildlife Service ranger's camp within Kisere forest to provide proper surveillance to the forest. Chism and cords in 1996 had recommended enforcement of law against cattle grazing within Kisere forest. This can only be realized through frequent and on ground surveillance by KWS rangers.

The road network linking Kisere area to other main roads should also be improved. This can be done by imposing a road levy on companies who collect sugar from farms around Kisere forest. This will enable the farms to access markets for their farm produce and ease surveillance of the forest by the concerned authorities. Tourism within Kisere forest will only possible if the roads system is upgraded.

Conservation groups should also come in to sensitize the local community that ecological value of forests is greater than the direct value from timber and non-timber products. This can also be extended to primary and secondary schools around Kisere forest.

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References

[1] Blackett, H. L. (1994). Forest Inventory Report no.3 Kenya Indigenous Forest conservation programme, Nairobi, Kenya
[2] Chism, J. B., & Cords M. (1998). Debrazza's Monkeys in the Kisere National Reserve, Kenya. *Journal of African primates* 3: 18-22
[3] Delang, C. O. (2006b). The role of wild food plants in poverty alleviation and biodiversity conservation in tropical countries. *Progress in Development Studies* 4: 275–286.
[4] Bambok E. & Martha Konje (2021). Impact of Anthropogenic Activities on Tree Species Density and Stem Size Distribution in Kisere Fragment of the Kakamega Forest, Kenya. *Researchjournali's Journal of Forestry*, Vol.8 (1): 1-15
[5] Fashing, J. F., Alison F., Christina S., & Marina C. (2004) Long-term tree population dynamics and their implications for the conservation of the Kakamega Forest, Kenya. *Journal of Biodiversity and Conservation*, 13: 753-771
[6] Godoy, R. A., & Bawa S. K., (1993). The Economic Value and Sustainable Harvest of Plants and Animals from the Tropical Forests: Assumptions, Hypotheses and Methods. *Journal of Economic Botany* 47: 215-219
[7] Hallberg, K. (2000). A Market-Oriented Strategy for Small and Medium Scale Enterprises. International Finance Corporation IFC Discussion Paper No. Washington, DC.
[8] Kiplagat, A. K. Mburu, J., & Mugendi, D. N. (2008) IASC International Conference 14-19 July 2008, University of Gloucestershire, Cheltenham, England
[9] Kokwaro, J. O. (1998) Conservation Status of Kakamega Forest in Kenya: The Easternmost relic of the equatorial rainforest of Africa. Monographs in systematic Botany Missouri Botanical Garden **25**: 471-489
[10] Koros Hillary, Itambo Malombe, Kaleb Mwendwa, Pascaline Jeruto, Humphrey Agevi, & Martha Konje. (2016b). Indigenous Knowledge, Uses and Conservation of Prunus Africana (Hook. F.) Kalkman in Nandi Forests. *Journal of Natural Sciences Research*.6 (14), 56-62.
[11] Koros, H., Konje, M. M., Wambua, M. M, Chesire, C. K., Odeny, D. & Malombe, I. B. (2016a). Population Status and Conservation Hotspots of *Prunus Africana* (Hook. F.) Kalkman in South Nandi Forest, Western Kenya. *Researchjournali's Journal of Forestry*, 3: 1-13
[12] Millet, J., & Luu H. T. (2011) Assessment of the Diversity and distribution of the threatened tree species in a logged forest in Vietnam. *Journal of Tropical conservation science* **4**: 82-96
[13] Mitchell, N. (2004) The Exploitation and Disturbance History of Kakamega Forest, Western Kenya: BIOTA report No.1
[14] Mitchell, N., Lung, T., & Schaab, G. (2008) Tracing significant losses and Limited Gains in Forest cover in the Kakamega – Nandi complex in Western
[15] Mmom, P. C. & Arokoyu, S. B. (2010) Mangrove Forest Depletion, Biodiversity Loss and Traditional Resources Management Practices in the Niger Delta, Nigeria. *Research journal of Applied Sciences, Engineering and Technology* **2**: 28-34
[16] Pankaj, K. (2009) Poverty alleviation by linking livelihood with microfinance practices for non-timber forest products. Indira Ghandi institute of development and research. Mumbai, India.
[17] Riana S. R, Tsin N. K, Ian G. & Charles N. (2009) Improving forest conservation and community livelihoods through income generation from commercial insects in three Kenyan forests. Kul Graphics publishers, Nairobi, Kenya
[18] Tsingalia, H. M. (1998) Animals and the regeneration of an African rainforest tree PhD Thesis. University of California, USA
[19] Von A., and Johana A. (2005). Human Impact on Flora and Vegetation of Kakamega forest, Kenya. A Phd thesis, Koblenz University-Landau.
[20] Vuyiya, Esther., Konje Martha., Tsingalia Harrison., Obiet Lenard., Kigen Charles., Wamalwa Stella., & Nyongesa Humphrey. (2014). Impact of human activities on tree species richness and diversity in Kakamega forest, Western Kenya. *International Journal of Biodiversity and conservation* **6:** 6 428-435